INTERNAL STRUCTURE OF THE EARTH,SEAFLOOR SPREADING AND PLATE TECTONICS

2025255015

OBSERVATION

- Seismic waves is the only way to understand the interior of the earth
- Seismic waves travel at different velocities and are reflected or refracted depending upon the nature of the medium through which they travel.
- Physical and chemical nature of the Earth vary with the depth. In general the Earth is composed of three distinct layers – **crust, mantle and core.** T

EVIDENCE FOR THE INTERIOR

Seismic waves:

1)Earthquake waves shows clearly that the Earth is zoned.

2)They are reflected and refracted at the boundaries between the zones.

3)These sharp breaks are called ‘discontinuities’.

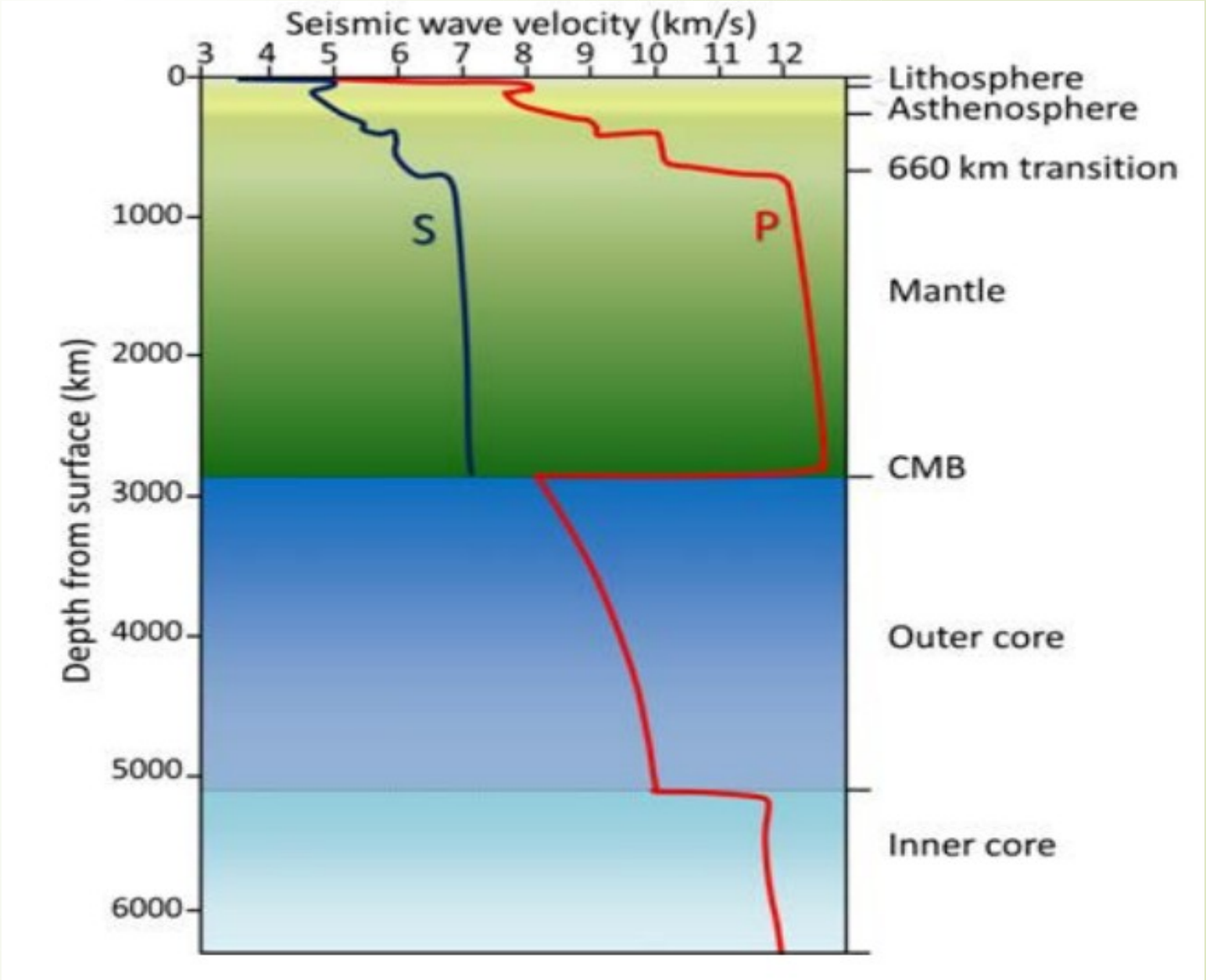
SEISMIC WAVES-TYPES

Three kinds of Seismic waves:

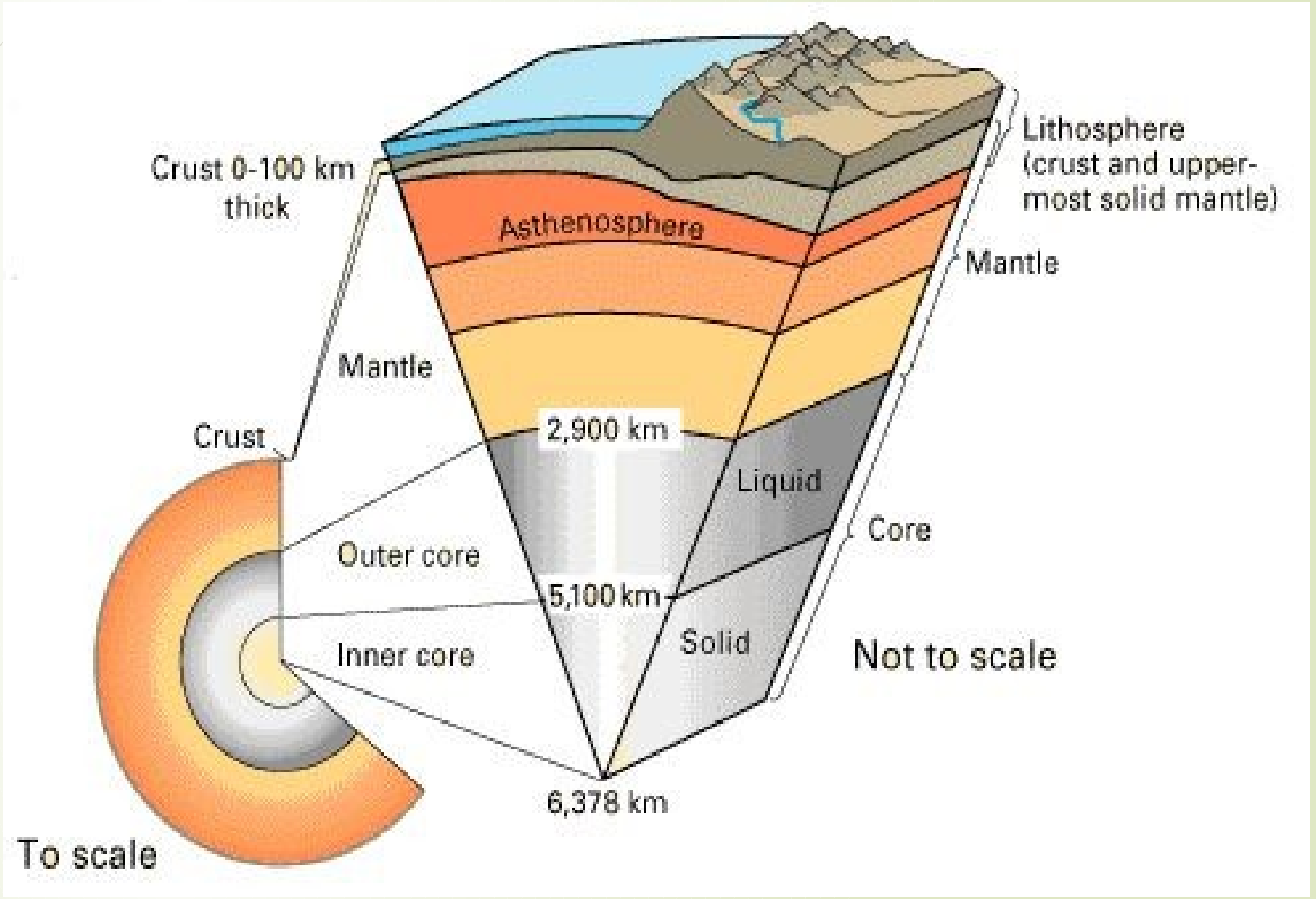
1)Primary waves – pass through solid and liquid

2)Secondary waves – do not pass through liquid

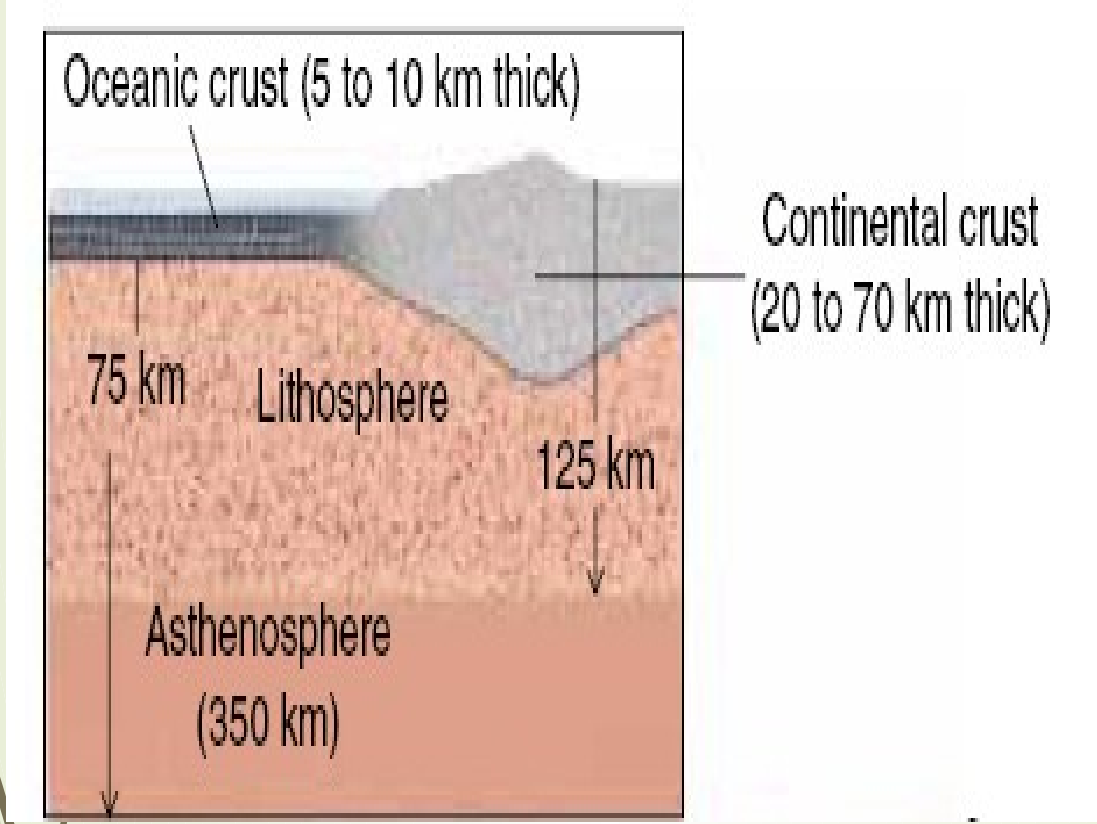
3)Surface waves – travel along near surface


Seismic wave velocity (km/s)
3
4
5
6
7
8
9
10
11
12
0
1000
2000
3000
4000
5000
6000
Depth from surface (km)
S
P
Lithosphere
Asthenosphere
660 km transition
Mantle
CMB
Outer core
Inner core

INTERNAL STRUCTURE OF EARTH



THE CRUST:



- Upper most layer and thinnest layer
- Because the crust is relatively cool, it consists of hard, strong rock.
- Thickness varies from 5 to 70 km
- Thickness beneath the ocean bottom is 5-8km is composed mostly of a dark, dense rock called **basalt** in top layer and **gabbro** in lower layer
- Thickness in the continent is 30-70 km and they are composed primarily of a light-colored,less dense rock called **granite**.
- Crustal thickness increases with the increase in the elevation.

- The composition in continental crust is Sial (silica + aluminium) & composition in the oceanic crust is Sima (silica + magnesium)
- Velocity of ‘P’ wave is 6.1 and 6.8kps
- Velocity of ‘S’ wave is 3.4 and 4.4kps
- P&S wave attain the greater velocity at a depth of 65 km. This mark the base of crust. It is konown as ‘Mohorovic Discontinuity’ or Moho

- **THE MANTLE:**
- Begins from the **Mohorovičić discontinuity(**Moho).
- It is almost 2900 kilometers thick and makes up 80 percent of the Earth's volume.
- P & S wave velocities jumps to 8.1 and 4.5 kps respectively.
- This is due to change in the nature of the material.
- The chemical composition may be similar throughout the mantle, Earth temperature and pressure increase with depth.
- Peridotite is the rock type found in the mantle.
- The uppermost mantle is relatively cool and consequently is hard, strong rock.
- In fact, its mechanical behavior is similar to that of the crust.
- The outer part of the Earth, including both the uppermost mantle and the crust, make up the lithosphere

ASTHENOSPHERE/LOW VELOCITY ZONE

- From 65-250 km the wave velocities decrease indicating semi-solid nature
- P-wave reduces from 8.1 to 7and again increases 8.1 at 250km
- Here the temperature is high enough to make peridotite mobile.

LOWER MANTLE

- It is magnesium-iron silicate
- From the depth of 1000 to 2900km
- P-wave increases from 8.1 to 14kps

THE CORE

- Begins from 2900km.
- The **core** is the innermost of the Earth’s layers. It is a sphere with a radius of about 3470 kilometers and is composed largely of iron and nickel.
- The outer core is molten because of the high temperature in that region.
- The pressure is greater than 1 million times that of the Earth’s atmosphere at sea level. The extreme pressure overwhelms the temperature effect and compresses the inner core to a solid.
- At this depth wave velocity decrease from 13.7 to 8.1. This denotes that phase change.
- Boundary of mantle and core is marked by **Weichert-gutenberg discontinuity.**
- Outer and inner core boundary lies at 5000km and it is known as **Lehmann discontinuity**

Table 2–2 • THE LAYERS OF THE EARTH

	LAYER	COMPOSITION	DEPTH	PROPERTIES
Crust	Oceanic crust Continental crust	Basalt Granite	5–10 km 20–70 km	Cool, hard, and strong Cool, hard, and strong
Lithosphere	Lithosphere includes the crust and the uppermost portion of the mantle	Varies; the crust and the mantle have different compositions	75–125 km	Cool, hard, and strong
Mantle	Uppermost portion of the mantle included as part of the lithosphere	Entire mantle is ultramafic rock. Its mineralogy varies with depth		
	Asthenosphere		Extends to 350 km	Hot, weak, and plastic, 1% or 2% melted
	Remainder of upper mantle		Extends from 350 to 660 km	Hot, under great pressure, and mechanically strong
	Lower mantle		Extends from 660 to 2900 km	High pressure forms minerals different from those of the upper mantle
Core	Outer core	Iron and nickel	Extends from 2900 to 5150 km	Liquid
	Inner core	Iron and nickel	Extends from 5150 km to the center of the Earth	Solid

PLATE TECTONICS

Theory of Plate Tectonics

- As significant to geology as relativity to physics, atomic theory to chemistry, or evolution to biology

Development:

- 1967: McKenzie and Parker suggested the theory
- 1968: Morgan outlined the theory
- Replaced 'continental drift theory' with 'convectional current theory' and 'sea floor spreading theory'

- Lithosphere Broken into distinct plates floating on the asthenosphere

- Plate Movement: Horizontal movement of plates over the asthenosphere as rigid units
- Includes crust and upper mantle
- Thickness: 5-100 km (oceanic), 200 km (continental)

Plate Types:

- Oceanic plates (Simatic crust, thinner)
- Continental plates (Sialic material, thicker)
- Combination plates (e.g Indo-Australian plate)

Consequences of Plate Movement:

- Earthquakes
- Volcanism
- Orogeny (mountain formation)
- Ocean opening and closing

Rate of Plate Movement:

- The Arctic Ridge has the slowest rate (less than 2.5 cm/yr)
- the East Pacific Rise in the South Pacific, has the fastest rate (more than 15 cm/yr).
- Indian plate’s movement during its journey from south to equator was one of the fastest plate movements.

Force for the plate movement:

- The slow movement of hot, softened mantle that lies below the rigid plates is the driving force behind the plate movement.
- The heated material rises to the surface, spreads and begins to cool, and then sinks back into deeper depths.
- This cycle is repeated over and over to generate what scientists call a convection cell or convective flow.
- Heat within the earth comes from two main sources: radioactive decay and residual heat.
- Arthur Holmes first considered this idea in the 1930s, which later influenced Harry Hess' thinking about seafloor spreading.

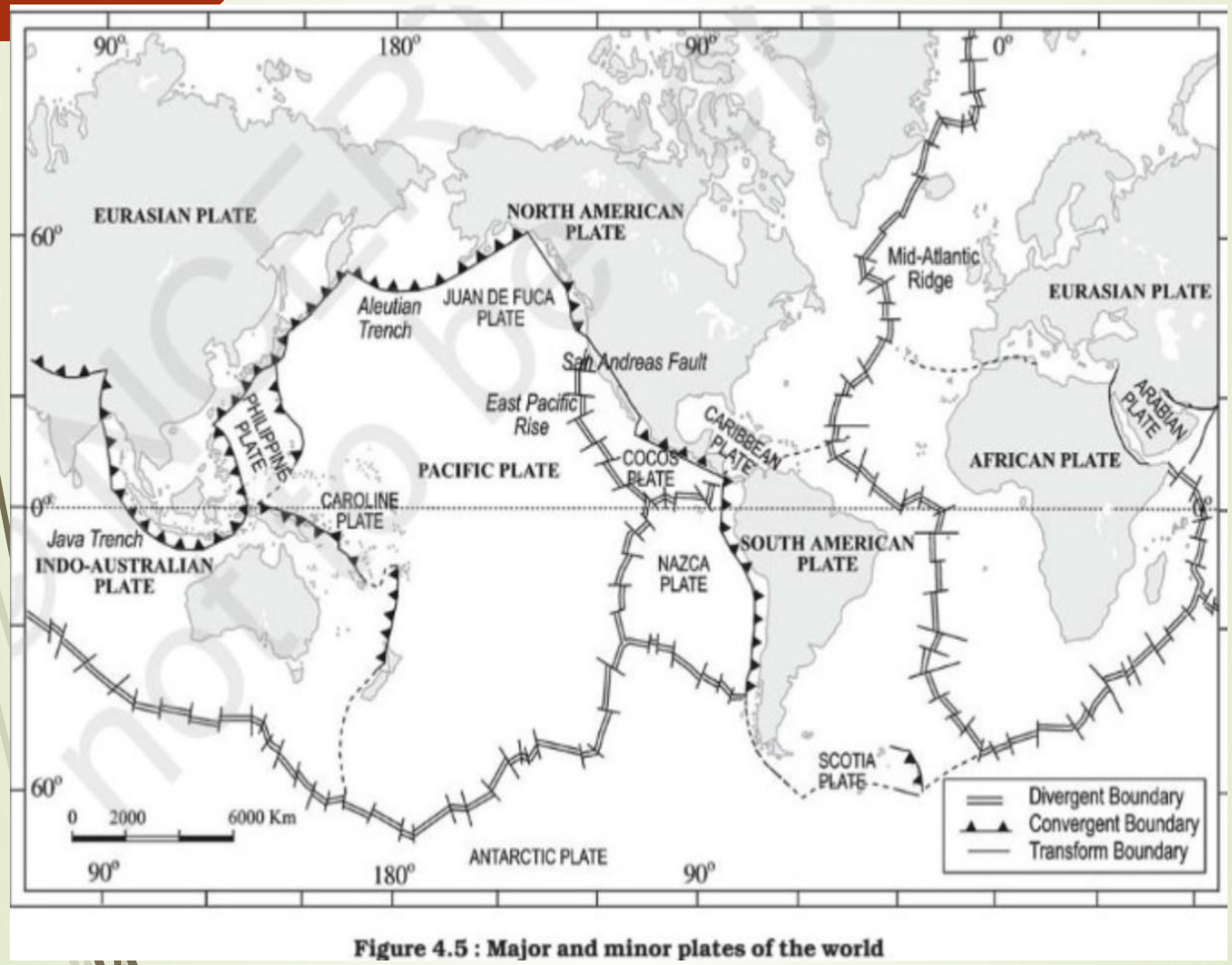


Figure 4.5 : Major and minor plates of the world

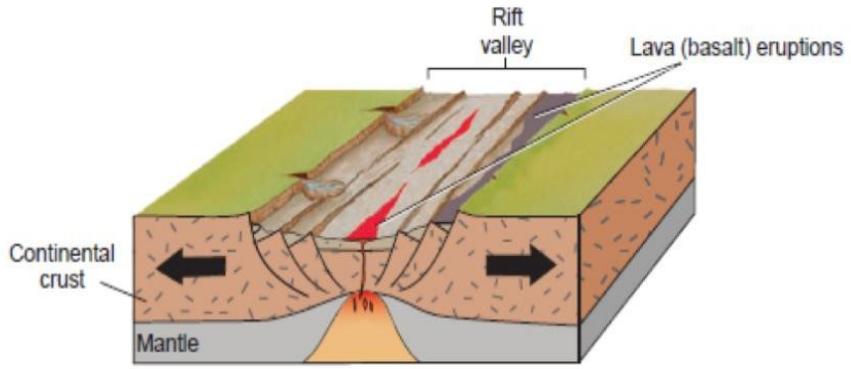
Major tectonic plates:

1. Antarctic plate
2. North American plate
3. South American plate
4. Pacific plate
5. India-Australia-New Zealand plate
6. African plate
7. Eurasian plate

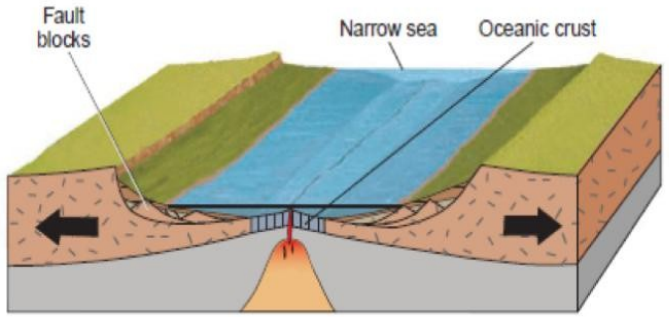
TYPES OF PLATE BOUNDARIES

- There are three types of plate boundaries, they are:

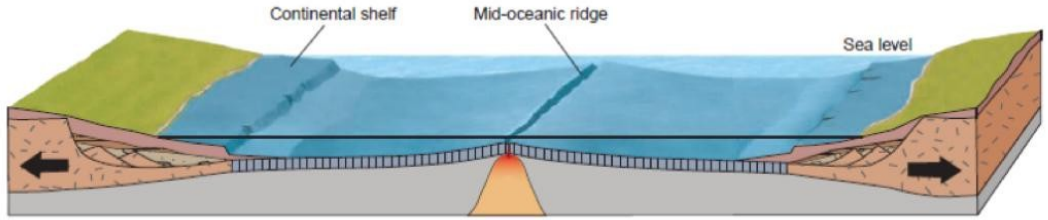
- Divergent boundaries
- Convergent boundaries
- Transform boundaries



A–Continent undergoes extension. The crust is thinned and a rift valley forms.



B–Continent tears in two. Continent edges are faulted and uplifted. Basalt eruptions form oceanic crust.



C–Continental sediments blanket the subsiding margins to form continental shelves. The ocean widens and a mid-oceanic ridge develops, as in the Atlantic Ocean.

C- Continental sediments blanket the subsiding margins to form continental shelves and
formation of Mid Oceanic Ridge.

Divergent Plate Boundaries

- Two plates moving apart from each other
- Mostly form mid-oceanic ridges (e.g., Mid-Atlantic Ridge)
- Can initiate within continents (e.g., East African Rift Valley)

Characteristics:

- Shallow earthquakes (small to moderate)
- Creation of new oceanic crust
- Volcanic activity (magma

Process of Formation:

1.Continental Rifting:

- Caused by extensional forces or upwelling of hot asthenosphere
- Continental plate pulls apart and thins

2. Narrow Valley Formation:

- Fissures develop, magma flows in
- Magma erupts onto the floor of the rift

3. New Ocean Floor Creation:

- Solidification of magma in fissures
- Eruption on the ocean floor

Example: east african rift valley

Rate of Motion: 1-18 cm/year (geologically fast)

Convergent Plate Boundaries

- Plates move toward each other
- Destruction of old sea floor, no change in Earth's size

Geologic Activities:

- Large earthquakes
- Mountain building (e.g., Andes range)
- Volcanic activity

Types of Convergent Boundaries:

- Ocean-continent convergence
- Ocean-ocean convergence
- Continent-continent convergence

- Density difference between oceanic and continental rock

- Examples: Andes mountain range

Ocean-Continent Convergence

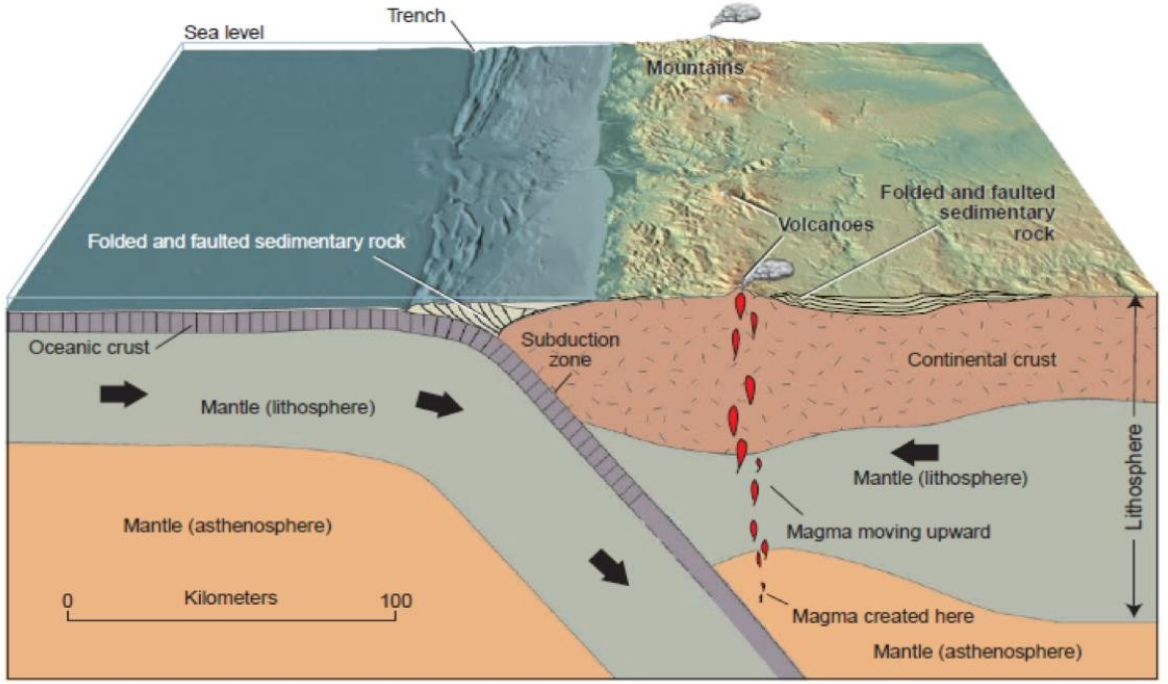


Figure.4 Ocean-Continent Conver

- If one plate is capped by oceanic crust and the other by continental crust, the less-dense, more-buoyant continental plate will override the denser, oceanic plate (Figure.4).

- The oceanic plate bends beneath the continental plate and sinks along what is known as a subduction zone, a zone where an oceanic plate descends into the mantle beneath an overriding plate.

- Deep oceanic trenches are found

OCEAN TO OCEAN CONVERGENCE

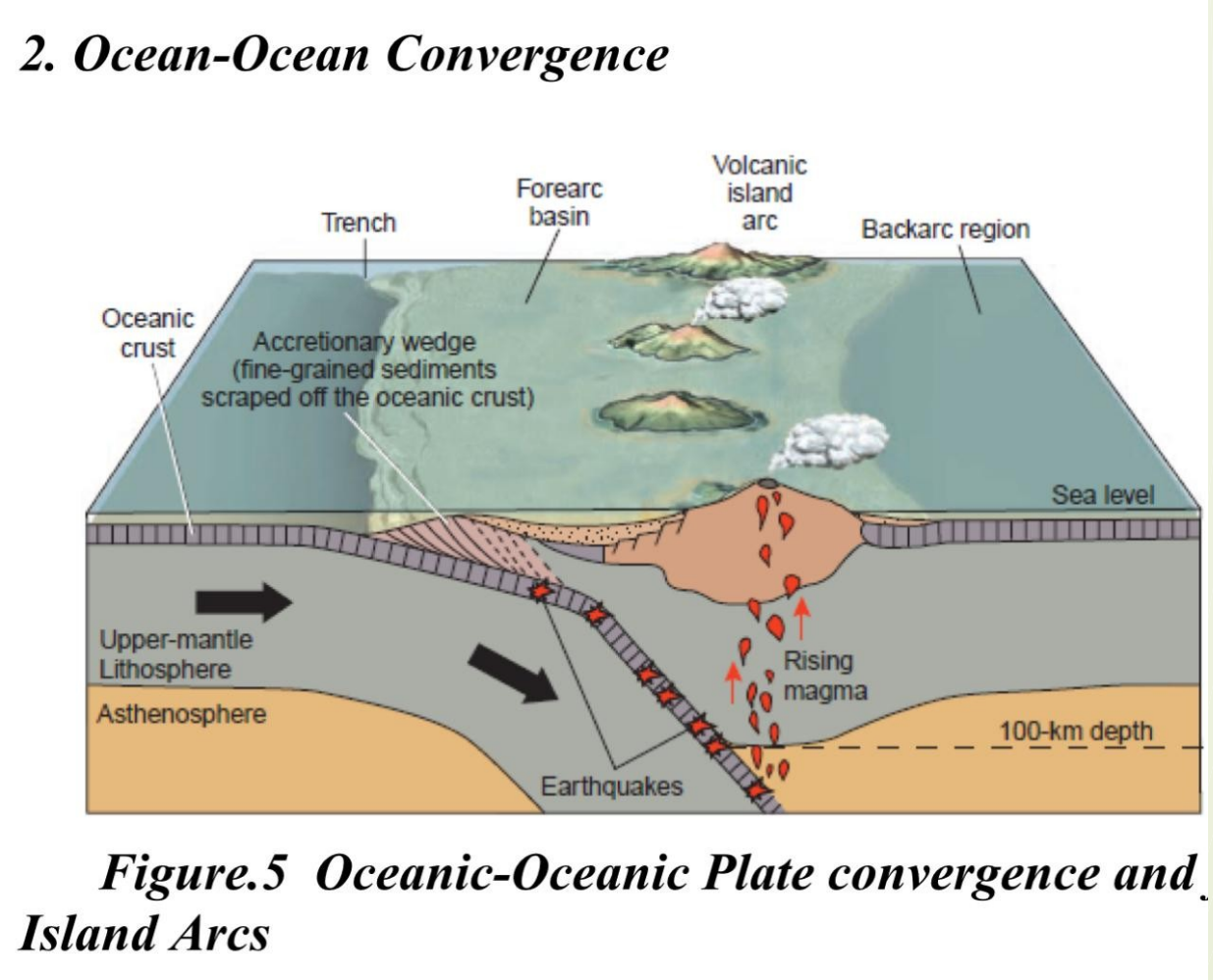
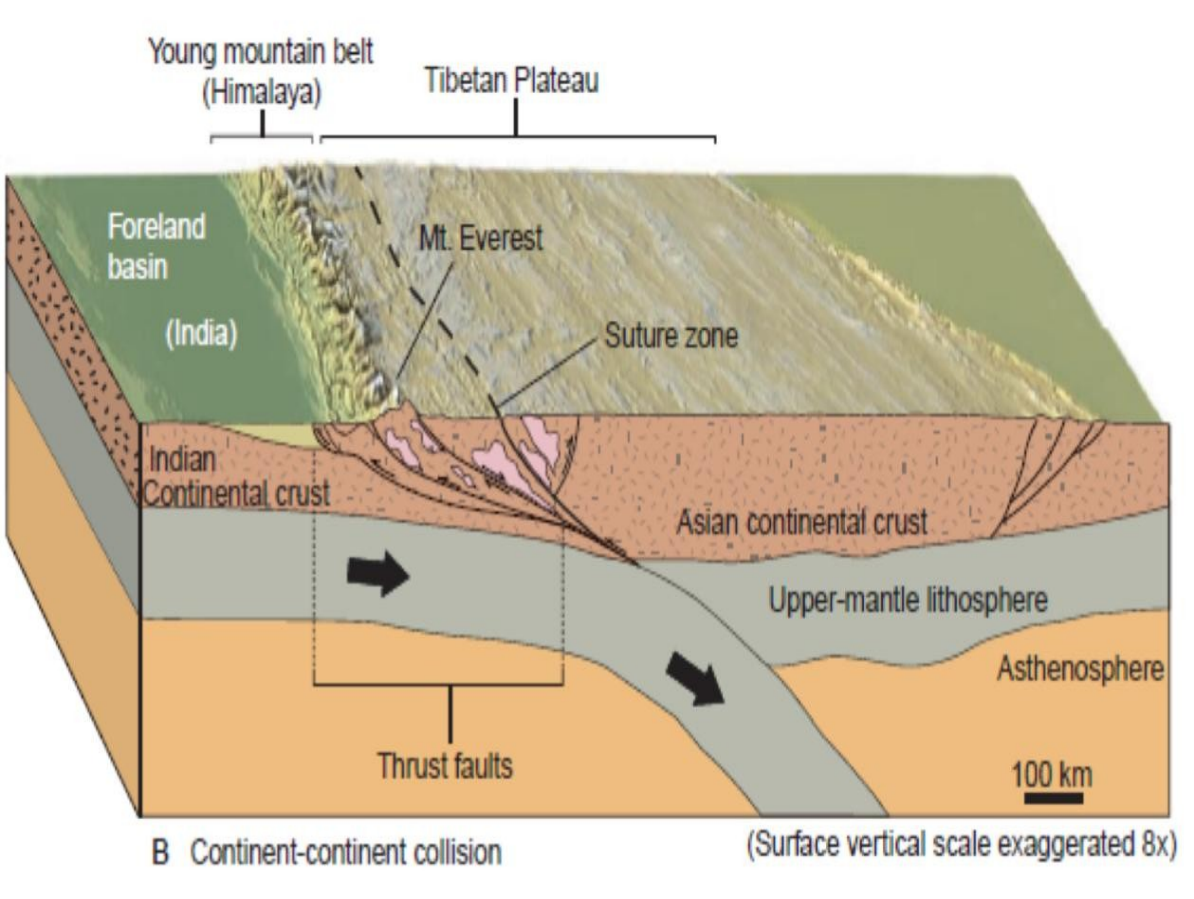


Figure.5 Oceanic-Oceanic Plate convergence and Island Arcs

- If both converging plates are oceanic, the denser plate will subduct beneath the less-dense plate (Figure.5).
- After subduction begins, molten rock is produced just as it is in an ocean-continent subduction zone;
- however, in this case, the rising magma forms volcanoes that grow from an ocean floor rather than on a continent.
- The resulting mountain belt is called a volcanic island arc.

Continent - Continent Convergence



1)If both the converging plates are continental different type of geological features are formed.

2) The continental lithosphere is much less dense than the mantle below. and, therefore, neither plate subducts.

3) The buoyant nature of continental lithosphere causes the two colliding continental plates to buckle and deform with significant vertical uplift and thickening as well as lateral shortening.

Transform fault boundary:

- It occurs where two plates slide horizontally past each other, neither toward nor away from each other.

- The San Andreas fault in California is an examples of this type of boundary.

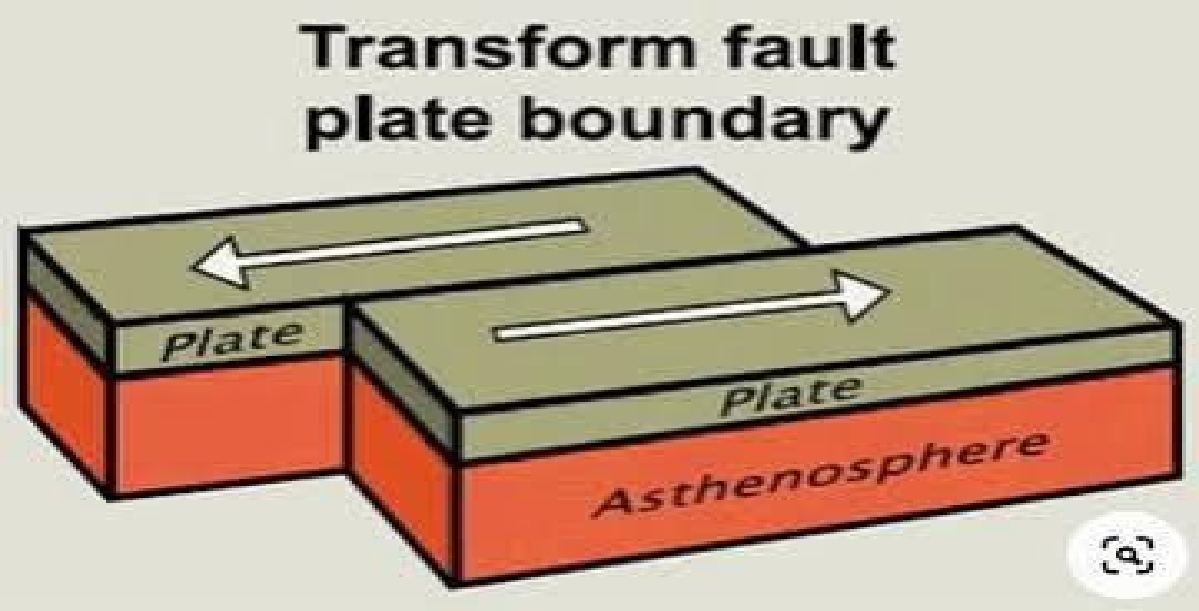


Table 2–1 • CHARACTERISTICS AND EXAMPLES OF PLATE BOUNDARIES

TYPE OF BOUNDARY	TYPES OF PLATES INVOLVED	TOPOGRAPHY	GEOLOGIC EVENTS	MODERN EXAMPLES
Divergent	Ocean-ocean	Mid-oceanic ridge	Sea-floor spreading, shallow earthquakes, rising magma, volcanoes	Mid-Atlantic ridge
	Continent-continent	Rift valley	Continents torn apart, earthquakes, rising magma, volcanoes	East African rift
Convergent	Ocean-ocean	Island arcs and ocean trenches	Subduction, deep earthquakes, rising magma, volcanoes, deformation of rocks	Western Aleutians
	Ocean-continent	Mountains and ocean trenches	Subduction, deep earthquakes, rising magma, volcanoes, deformation of rocks	Andes
	Continent-continent	Mountains	Deep earthquakes, deformation of rocks	Himalayas
Transform	Ocean-ocean	Major offset of mid-oceanic ridge axis	Earthquakes	Offset of East Pacific rise in South Pacific
	Continent-continent	Small deformed mountain ranges, deformations along fault	Earthquakes, deformation of rocks	San Andreas fault

Seafloor spreading

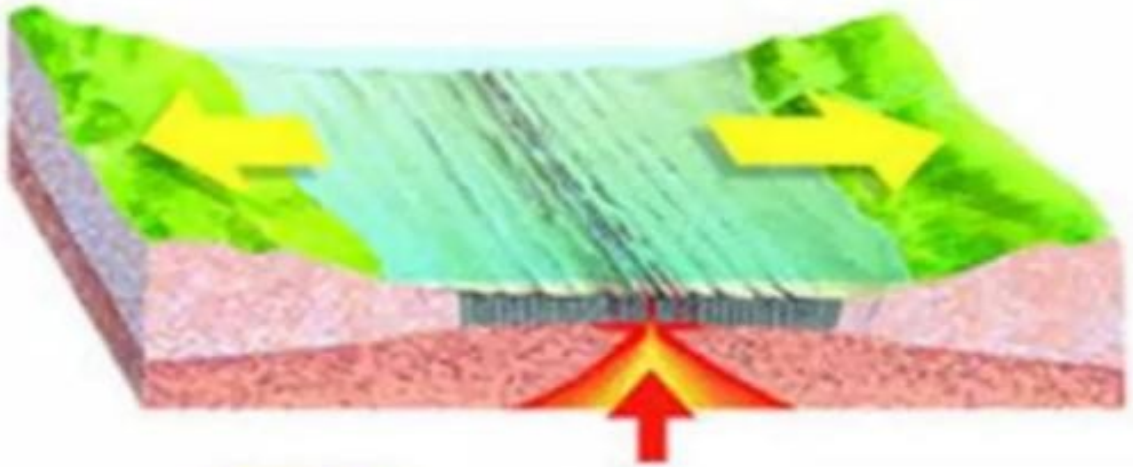
SEAFLOOR SPREADING

- Sea-floor spreading is the process in which the ocean floor is extended when two plates move apart.

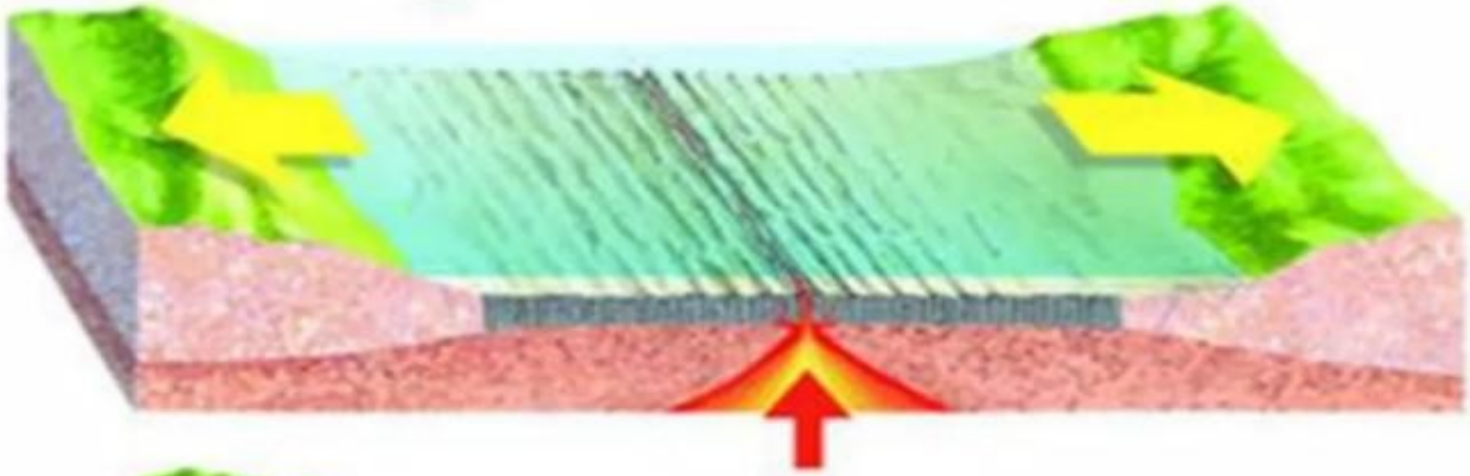
- As magma seeps out between the plates, it solidifies and extends the ocean floor and creates a long chain mountain called the Mid-Oceanic Ridge.

Sea Floor Spreading Hypothesis:

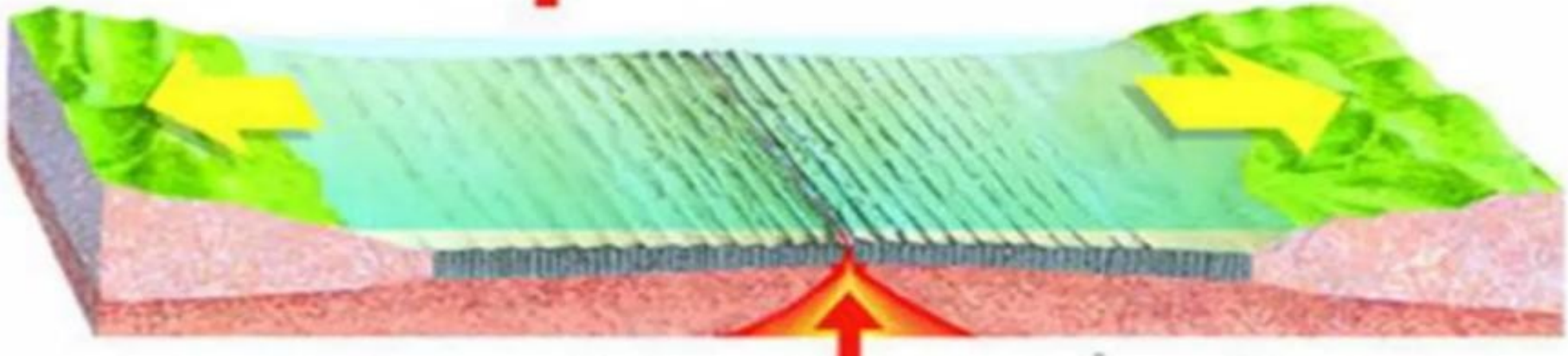
Proposed by Harry H. Hess in 1960, he hypothesized that the formation of underwater mountains and new ocean floors were caused by the Earth's mantle rising up between two plates.



The boundaries where the plates move apart are 'constructive' because new crust is being formed and added to the ocean floor.



The ocean floor gradually extends and thus the size of these plates increases.



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